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"INFRARED BACKBONE COMMUNICATION
NETWORK HAVING A RADIO FREQUENCY
BACKUP CHANNEL"

BACKGROUND OF THE INVENTION

The present invention relates generally to a
5 communication network used to maintain communication
exchanges within an enclosed premises; and, more
particularly, it relates to a method and apparatus for
maintaining communication exchanges utilizing both
infrared and radio frequency transmissions in a
10 premises such as an office building, hospital, factory
floor, or the like.

As is well known, radio frequency (RF)
transmissions have been used to maintain point to
point communication. However, use of RF transmissions
15 in a premises can cause several problems. For
example, RF transmissions can interfere with the
proper functioning of other equipment in the premises.

Such interference is particularly undesirable in a
premises such as a hospital, where the equipment may
20 provide life support to patients. Further, because
the Federal Communication Commission (FCC) has
allocated only certain frequencies to premises RF

communication networks, interference may also occur between adjacent premises. Thus, RF communication in a premises may be hindered by RF noise from surrounding premises. Such noise may become a significant burden to communication in a premises located in a crowded, city environment.

These interference problems may also be enhanced given the physical layout of most premises. Specifically, a typical premises comprises structural supports and walls which limit the penetration of RF transmission. If the transmission power is too low, certain areas may arise wherein RF transmissions cannot be received (i.e., "dead zones"). While increasing the RF transmission power may increase penetration and eliminate dead zones, it also increases the likelihood that the above-described interference problems may occur.

In addition, increasing the RF transmission power may also be undesirable for health reasons. Specifically, it has been alleged that RF transmissions may potentially cause damage to human tissue or cells, and thus may be carcinogenic. As a result, it may be desirable to not only limit the RF transmission power in a premises, but also limit the use of RF transmissions altogether.

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As is also well known, modulated infrared light has also been used to maintain point to point communication. Use of infrared light as such in a premises is a desirable alternative to RF transmissions because infrared light is rather harmless to humans and does not cause the interference problems discussed above. However, use of infrared light for communication in a premises causes a unique set of problems. For example, infrared communication is limited in range because it is directional, i.e., it requires "line of sight" type transmissions. As a result, it is difficult to provide communication over an entire premises using only infrared transmissions.

In addition, dead zones are created easily in infrared systems by mere interruption of the light stream, resulting in a loss of data.

While infrared systems are less expensive than those using RF, they are not a viable alternative to RF because of these problems. Infrared communication has had virtually no market use in mobile environments, and has only been a solution to replacing RS232 and parallel wiring in short distance, line of sight environments such as between a personal computer and associated input and output devices (e.g., keyboard, mouse, printer, etc.).

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In airplanes, the use of electronic equipment is permitted but with many restrictions. For example, during take off and landing, all such equipment must be turned off to prevent unintentional yet often
5 inherent RF transmissions from interfering with cockpit electronics. Such interference proves annoying yet is tolerated by cockpit crews during the less critical period between take off and landing. Moreover, at all times during flight, airlines
10 prohibit passengers from using intentional, RF transmissions within an airplane.

As a result, while in flight, passenger are virtually cut-off from their normally available communication and data channels outside of the
15 airplane. Similarly, two or more passengers on the same flight are prevented from wirelessly networking unless their electronic equipment is either within line of sight of the other's equipment (for infrared communications) or within very close proximity (for a
20 wired linkup). However, many types of wired communication links are designed with maximum bandwidth for rapidly exchanging data. Higher bandwidth, usually results in higher emission levels of unintentional RF energy. Thus, such wired links
25 are not desirable within airplanes.

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-5-

Because such line of sight and proximity conditions cannot be guaranteed, networking involving a plurality of passengers within airplanes rarely proves viable. With little or no means of communicating, passengers are often unproductive, bored and/or anxious.

Also during flight, through monthly magazine publications, airlines offer duty free or other items for sale, provide information regarding in-flight services and provide route and terminal information. Flight attendants are burdened with assisting passengers in finding, understanding and supplementing such information. The attendants must also assist passengers by taking orders for the items being purchased. Because flight attendants are busy with many other tasks, passengers often forego purchasing and requesting information while in flight.

Airlines also desire to provide further booking or travel agency services to passengers while in-flight. Such services are accessible via telephones within the airplanes, but, because of the limited voice interface, utilization has not meet expectations.

Hence, it would be highly desirable to solve the foregoing variety of enumerated problems while maintaining reliable communication exchanges between a

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plurality of devices operating within an enclosed premises. It is therefore an object of the present invention to provide a method and apparatus which minimizes the need for RF communication while at the same time maximizes the benefits obtained from infrared communication.

It is another object of the present invention to provide a method and apparatus for maintaining communication in a mobile environment using both infrared and RF transmissions.

Another object of the present invention is to provide a method and apparatus for permitting airplane passengers to maintain communication connectivity during flight to local and remote information and services, other passengers and remote associates, without interfering with cockpit equipment.

Other objects, advantages, and novel features of the present invention will become apparent from the following detailed description of the invention and claims with reference to the accompanying drawings.

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SUMMARY OF THE INVENTION

These and other objects of the present invention are achieved in a backbone network used within a premises having at least two separate areas to maintain communication among end-point devices. The network comprises a tap access point, located within the second area, having both an infrared transceiver and a radio frequency transceiver. The network further comprises an antenna, located in the first area, which is electrically connected to the radio frequency transceiver. The tap access point uses the infrared transceiver to communicate in the second area, and the radio frequency transceiver and antenna to communicate in the first area.

The network may also comprise a second antenna, located within the second area, which is electrically connected to the radio frequency transceiver for communicating using the radio frequency transceiver in the second area.

The network may further comprise at least one hub access point, located in the first or the second area, which communicates with the tap access point. Each hub access point has an infrared transceiver for establishing infrared communication and a radio transceiver for establishing radio frequency communication. At least one of a plurality of hub

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access points is communicatively coupled to the tap access point, and each of the plurality of hub access points selectively chooses between the infrared and radio frequency communication to maintain communication in the network. The hub access points may communicate via infrared whenever possible, and otherwise communicate via radio frequency, or vice versa, i.e., communicate via radio frequency whenever possible, and otherwise communicate via infrared.

10 In addition, the network may also comprise a panel which minimizes interference from unwanted infrared transmissions.

Other objects are also achieved in a communication network comprising a plurality of access points, each having an infrared transceiver to selectively establish a first communication channel and a radio frequency transceiver to selectively establish a second communication channel. The network further comprises a plurality of end-point devices configured for infrared or radio frequency communication or both. A communication protocol is used by each access point for directing the establishment of either the first communication channel or the second communication channel as needed to maintain communication with the end-point devices or other of the access points.

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The communication protocol, when used for communication among a plurality of access points may first direct the establishment of the first communication channel and, if communication using that channel fails, direct the establishment of the second communication channel. Of course the network may also do the opposite, i.e., first direct the establishment of the second communication channel, if the second channel fails, then direct the establishment of the first communication channel. The communication protocol may comprise, for example, a polling protocol.

At least one of the access points may comprise a tap access point, which is located in a first area for communication using the first communication channel, and which is connected to an antenna located in a second area for communication using the second communication channel. The tap access point may also be connected to another antenna located in the first area for communication therein using the second communication channel.

In another embodiment, a communication network for maintaining communication among a plurality of end-point devices in an environment sensitive to RF interference illustrates other aspects of the present invention. In particular, the

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communication network comprises a plurality of end-point devices and a communication pathway having a plurality of access point devices. The communication pathway supports communication among the plurality of
5 end-point devices. Also within the network, a device sensitive to RF interference and a control link coupled to thereto can be found. Signals indicative of acceptable levels of RF interference are communicated through the control link. The
10 communication pathway is capable of selectively generating different levels of RF interference, and does so based on the signals communicated via the control link.

Further aspects of the present invention can
15 be found with the addition of a server to the communication network. The server responds to said control link to relaying the signals indicative of acceptable levels of RF interference along the communication pathway. The server may also provide
20 the plurality of end-point devices access to local and remote resources.

In a specific embodiment, the communication network constitutes an airplane. Therein, each of the plurality end-point devices constitutes a portable
25 computer having an infrared transceiving pair. Similarly, said plurality of access points each have a

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plurality of infrared transceiver pairs disposed within the airplane to support communication with ones of the plurality of end-point devices.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates an embodiment of the communication network of the present invention, representing communication throughout a floor of a hospital or office building.

Figs. 2a-e illustrate several perspective views and embodiments of access points according to the present inventions which are capable of providing both radio frequency and infrared transmission and reception.

Fig. 3 is a cross sectional view illustrating a portion of a communication network according to one embodiment of the present invention, wherein the access points of Figs. 2a-e are implemented.

Figs. 4a-d are cross sectional views which illustrate several other possible network configurations of the present invention using the access points of Figs. 2a-e.

Fig. 5 provides a cross sectional illustration of another configuration of the present invention using the access points of Figs. 2a-e in a hospital environment.

Fig. 6 provides another cross sectional illustration of a configuration of the present invention using the access points of Figs. 2a-e in an office environment.

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Figs. 7a-b provide perspective views illustrating two different backbone network configurations built in the hallways of an exemplary building in accordance with the present invention, and, specifically, illustrate the communication exchange between specific rooms or offices and the backbone network.

Fig. 7c is a cross sectional top view of the hallway of Fig. 7b illustrating the infrared diode layout in the access points of the present invention.

Fig. 7d provides a cross sectional view illustrating the interaction of an infrared transmission of a laser diode with a panel.

Fig. 8 is a timing diagram illustrating a polling protocol used to maintain communications through one embodiment of the communication network of the present invention.

Fig. 9 is a timing diagram illustrating the adaptive nature of the polling protocol used in the selection of infrared and RF communication links.

Fig. 10 is a block diagram representing the circuitry found in access points constructed in accordance with the present invention.

Fig. 11 is a top cross-sectional view of an airplane configured with the access points of the present invention installed in a communication network having a server which interfaces with cockpit

-14-

equipment.

Fig. 12 is a front cross-sectional view of the airplane of Fig. 11 illustrating access point and infrared transceiver pair positioning.

5 Fig. 13 is a perspective view of an overhead control panel modified in accordance with the present invention to accommodate a infrared transceiver pair.

Fig. 14 is a block diagram of the communication network in the airplane of Fig. 11 detailing the
10 functionality and interaction of the server.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 illustrates an embodiment of the communication network of the present invention, representing communication throughout a floor of a hospital or office building. In particular, a building 101 is configured with a communication network according to the present invention to provide communication between a plurality of devices (not shown) located in any of the rooms, such as rooms 103, 105, 107 and 109, in the building 101. Although in some embodiments, the room 109 may constitute a communication center, in other embodiments, the room 109 is no different than any other room. To support such communication, a backbone network is constructed from a plurality of hub access points 111, 113, 115, 117 and 119 which are built in accordance with the present invention.

Figs. 2a-e illustrate several views and embodiments of access points according to the present inventions which are capable of maintaining both radio frequency and infrared transmission and reception. These access points may be used in the communication network, for example as illustrated in Fig. 1, (i) solely for infrared communication, (ii) solely for radio frequency communication, or (iii) for both radio frequency and infrared communication.

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Specifically, in Fig. 2a, an access point consists of a main module 203 and a cap 205. The main module 203 contains all access point circuitry (see the description associated with Fig. 9 below), while the cap 205 constitutes a cover which is transparent to infrared transmissions. In an alternate embodiment, the cap 205 also diffuses infrared transmissions. The cap 205 contains a hole 207 for receiving an antenna 209, if needed, as shown in Fig. 2b.

Fig. 2c is a perspective view of the access point 201 for illustrating the location and existence of a power cord 211, a coaxial connector 213 and a telephone jack 215. The coaxial connector 213 may be used to establish an alternate antenna configuration as detailed below in reference to Figs. 4c and 4d. The telephone jack 215 is also provided for maintaining wired communication between access points (see the description associated with Fig. 3 below). Although the power cord 211 supplies AC (Alternating Current) power to the access point 201, in another embodiment, the access point 201 utilizes a battery power supply.

Figs. 2d and 2e illustrate two versions of the access point 201 with the cap 205 removed. In particular, in Fig. 2d, a main module 203A of a hub

access point 201A contains a plurality of infrared transmitter and receiver pairs, such as a laser diode 217 and a photo-transistor 219. Although other designs are contemplated, the laser diodes, such as the laser diode 217, are fitted with lenses and apertures so as to provide a infrared light throughout a forty five (45) degree angle of emission. Thus, to cover the entire three hundred and sixty (360), degrees, eight (8) laser diodes are needed (with a five degree overlap between each diode). In addition, a coaxial connector 221 provides for the connection of an antenna, such as the antenna 209 (Fig. 2b), when needed.

In Fig. 2e, a main module 203B of a tap access point 201B is shown. Instead of providing for infrared communication in all directions, such as is the case with the hub access point 201A (Fig. 2d), the tap access point 201B provides for communication from a single infrared transmitter and receiver pair, i.e., a laser diode 223 and a photo-transistor 225. As with the hub access point 201A, the tap access point 201B also has a coaxial connector, a coaxial connector 227, which provides for the connection of the antenna 209 when needed.

Fig. 3 illustrates one embodiment of the present invention which illustrates a portion of a

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communication network utilizing the access points of Figs. 2a-e. Specifically, Fig. 3 illustrates a cross sectional view of a building, such as the building shown in Fig. 1. The cross section illustrates a hallway 301 which separates offices or rooms, such as a room 303 and a room 305. Communication along the hallway 301 is maintained by a backbone network established by hub access points. A hub access point 307, installed on a ceiling, constitutes one member of the backbone network. Other hub access points (not shown) are placed on the ceiling along the hallways of the building so that each hub access point can communicate with at least one other hub via a line of sight infrared link. Of course, the hub access points may also be configured to communicate on the backbone network via wired links through the telephone jacks 215 discussed above in reference to Fig 2C. An exemplary positioning of hub access points is shown in Fig. 1.

Each hub access point receives communication from other hub access points in a relaying fashion. For example, referring to Fig. 1, the hub access point 119 engages in communication exchanges with the hub access point 117 via the hub access point 115, providing a relaying pathway. Hub access points also communicate with tap access points which are used to direct

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communication into rooms or offices in a building. Specifically, referring back to Fig. 3, the hub access point 307 communicates with tap access point 309 and 311. In the illustrated embodiment the tap access points 309 and 311 receive communications via line of sight, infrared links with the hub 307 and relay such communications via wired link 313 and 315, respectively. If the infrared link fails, the hub access point 307 and the tap access points 309 and 311 will utilize a low-power RF communication link to maintain communication (see the discussion relating to Fig. 9 for further detail).

Tap access points 317 and 319 receive relayed communications from the tap access points 309 and 311, respectively, and further relay the communications to end-point devices. The tap access points 317 and 319 attempt to maintain infrared communication to the end-point devices. For example, the tap access point 317 attempts to maintain infrared communication with an end-point device 310 via an infrared transceiver 312.

However, if infrared communication becomes impossibly blocked, the tap access points 317 and 319 switch to low-power RF to maintain the communication link. For example, the tap access point 317 attempts to maintain RF communication with the end-point device 310 via an antenna and associated RF transceiver 314.

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-20-

In particular, each communication is first attempted using an infrared link. If the infrared link fails, the low-power RF link will be used. More detail regarding this process is illustrated in reference to Fig. 9 below. As can be appreciated, using infrared links whenever possible, RF transmission is minimized. Moreover, the RF transmissions that may occasionally occur are very low power, having only to span short, line of sight distances to destination (end-point) devices.

Although the illustrated configuration locates the tap access points 317 and 319 on the ceilings of the rooms 303 and 305 and by walls 304 and 306, respectively, the wired links 313 and 315 could be extended to locate the tap access points into the centers of the room or on any wall or table. Moreover, the tap access points 317 and 319 might also communicate with other access points located in the rooms 303 and 305. In fact, if the need arises, the tap access points 317 and 319 can be replaced with hub access points to extend the backbone network through wall barriers.

Figs. 4a-d illustrate several other possible network configurations of the present invention using the access points of Figs. 2a-e. In Fig. 4a, a hub access point 401 located on the ceiling of a hallway

-21-

uses only an infrared link to communicate with tap access points 403 and 405. This configuration has cost advantages over that illustrated in Fig. 3 because the access points 403, 405 and 401 need not be fitted with radio transceivers or antennas, yet has the disadvantage of not having a backup RF link. However, because of the location of the access points on the ceiling of the hallway 301, physical blocking of the infrared communications is minimized.

The tap access points 403 and 405 also utilize wired links 402 and 404 to communicate to tap access points 407 and 409, respectively, which are located in an enclosed office or room in the building. The wired links 402 and 404 constitute a telephone type cord which plugs into telephone jacks of the access points, and permit communication through walls 406 and 408, respectively. The tap access points 407 and 409 utilize infrared links with end-point devices in the rooms (not shown) when possible, and low-power RF links for backup.

Fig. 4b illustrates two embodiments of the present invention. The first relates to a room 416 in which the use of low-power RF transmission are acceptable. The other relates to a room 418 where no RF transmission is acceptable. In both embodiments, a hub access point 411 uses infrared transmissions in

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-22-

the backbone network, while using RF transmissions only as a backup. However, the hub access point 411 could also be configured to use RF transmissions for the backbone network with infrared transmission only as a backup.

Regarding the room 416, a tap access point 413 communicates with the hub access point 411 using only infrared transmissions. However, the tap access point 413 uses low-power RF transmissions in the room 416. Instead of placing additional tap access points in the rooms, as is shown in Fig. 4a, a coaxial cable 412 permits the location of an antenna 417 in the room 416 for low-power RF communication with end-point devices.

In this manner, the hub access point 411 is not forced to use a higher power RF transmission to cover the additional distances and to penetrate the wall of the room 416. Moreover, the walls of the room act to confine the low-power transmissions from the antenna 417 to the room.

In the room 418, infrared based communication with the hub access point 411 is established from end-point devices in the room 418 through tap access points 415 and 419. No RF communication is used. Thus, the tap access points 415 and 419 need not be fitted with RF transceivers or antennas.

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Fig. 4c illustrates an additional configuration of an infrared backbone network using RF transmissions for backup purposes. In this configuration, instead of using infrared, communication between a hub access point 421 and tap access points 423 and 425 occur solely through RF transmissions. Specifically, the tap access point 423 only communicates with end-point devices via infrared transmissions. The tap access point 423 communicates with the hub access point 421 via RF transmissions. Therefore, an antenna 427 is routed and placed outside of the room in the hallway. A wall 426 helps to contain the RF transmissions to the hallway.

The tap access point 425 also communicates with end-point 15 devices via infrared transmissions, but also uses RF transmissions as a backup. However, as can be appreciated, the tap access point 425 must be capable of supporting RF communication in both the hallway (with the backbone network), and for backup in the room (with end-point devices). This requires that the tap access point 425 be configured with either two independent RF transceivers or a single dual-purpose RF transceiver.

Fig. 4d illustrates yet other possible configurations of the present invention wherein the backbone network (comprising a plurality of hub access

-24-

points including a hub access point 431) utilizes RF transmissions only as a backup to infrared communication. The hub access point 431 communicates with tap access points 433 and 435 using infrared transmissions. The tap access point 433 is fitted with an RF transceiver and an antenna 437 so that RF communication backup is available to the hub access point 431. In addition, the tap access point 433 also communicates using RF transmissions to end-point devices via an antenna 439. Thus, the tap access point 433 is fitted with a dual-purpose RF transceiver. The tap access point 435 and associated antenna 441 communicates as does the tap access point 413 in Fig. 4b as described above.

Fig. 5 more fully illustrates another configuration of the present invention using the access points of Figs. 2a-e in a hospital environment.

Infrared transmissions are used to maintain the backbone network including a plurality of hub access points, such as a hub access point 501. The hub access point 501 also utilizes infrared transmissions to communicate to tap access points 503 and 505. The end-point devices, such as a hand-held terminal 507 and monitoring station 509, thus Communicate with the tap access point 503 (through its antenna 511) using RF transmissions. Because of the relatively small

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size of the room and the absence of substantial physical RF barriers such as separating walls, the RF transmission power required is very low. Such low levels are highly unlikely to harmfully affect any electronic equipment or patients in the room. Moreover, the walls of the room also help contain the low power transmissions so as to minimize interference with RF transmissions in the hallway or in adjacent rooms.

Fig. 6 illustrates another configuration of the present invention using the access points of Figs. 2a-e in an office environment. In an office 601, a tap access point 603 is centrally located so that interference with physical barriers, such as a dividing wall 605, is minimized. In the central location the tap access point 603 establishes line of sight, infrared communication with end-point devices fitted with infrared transceivers, such as a computer 607 and a printer 609. Also illustrated is a wired link 611 which interconnects the tap access point 603 in the office from a tap access point 613 in the hallway. Although the tap access point 613 illustrated does not use RF communication for backup, from the several examples given it is clear that it could.

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Figs. 7a-b are perspective views which illustrate two different backbone network configurations built in the hallways of an exemplary building in accordance with the present invention, and, specifically, illustrate the communication exchange between specific rooms or offices and the backbone network. In Fig. 7a, a hub access point 751 participates with other hub access points to maintain a backbone network. In particular, the hub access point 751 participates by relaying communication to and from another hub access point (not shown) located within line of sight further "down" the hallway. For frame of reference, a wall 752 is located "up" the hallway. Backbone network communicates using infrared transmissions, while using RF transmissions for backup purposes when infrared transmissions fail. The hub access point 751 also establish RF communication through the antennas 753, 755, 757 and 759 to tap access points inside the rooms (as detailed in Fig. 4c).

Because of its location, the hub access point 751 participates as a polled device in the backbone network through another hub access point (the polling device) located down the hall. However, the hub access point 751 also participates as a polling device when communicating with the tap access points connected to the antennas 753, 755, 757 and 759.

First, the hub access point 751 polls the tap access point associated with the antenna 753, and then polls the other tap access points in sequence. Thereafter, the hub access point 751 enters a "listening" state to detect infrared polling transmissions from a hub access point located down the hallway (not shown). After responding to a polling transmission if a response is necessary, the hub access point 751 repeats the cycle.

10 In Fig. 7b, a hub access point 701 forms a part of the backbone network by relaying communication to and from another hub access point (not shown) located within line of sight further down the hallway. A wall 702 is located up the hallway. The backbone network
15 employs infrared transmissions as a default, while using RF transmissions as a backup. The hub access point 701 provides tap access points 703, 705, 707 and 709 access to the backbone network. Such access also utilizes infrared transmissions, while using RF
20 transmission backup. Each of the tap access points 703, 705, 707 and 709 are connected to either other access points or other antennas located in the corresponding rooms (as detailed in the examples illustrated in Figs. 3-5).

25 To minimize infrared interference, expandable panels 711 and 713 are installed on the ceiling

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adjacent to the hub access point 701. The panels 711 and 713 expand in the horizontal direction to cover the distance between the hub access point 701 and a wall of the hallway. The panels 711 and 713 block infrared transmissions so that transmissions originating on one side of the panels are blocked from reaching access points on the other side of the panels. The color of the panels 711 and 713, a light grey, minimizes the amount of infrared transmission reflection. In addition, the panels 711 and 713 are triangularly shaped so as to reflect infrared transmissions downward, out of the plane of the access points. The hub access point 701 participates on both sides of the panels 711 and 713. In this manner, the expandable panels 711 and 713 create infrared communication cells having minimal noise characteristics. Note that another expandable panel (not shown) could also be placed against and along the ceiling of the wall 702 to deflect downward transmissions from the hub access point 701. However, because infrared transmission reflections from the wall 702 originating from the hub access point 701 rarely encounter the phototransistors of tap access points 703, 705, 707 and 709, the additional panel is not necessary in this circumstance.

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Fig. 7c is a cross sectional top view of the hallway of Fig. 7b illustrating the polling protocol and the infrared diode layout of the access points in one embodiment of the present invention. As discussed in more detail below in reference to Fig. 8, the hub access point 701 uses an exemplary polling protocol to manage communications. Because of the coverage constructs of the infrared laser diodes and the layout in the hallway, the hub need only use four of its eight pairs of infrared laser diodes and corresponding photo-transistors. In particular, upon receiving infrared communications from a hub access point 715 located down the hallway, the hub access point 701 identifies the phototransistor which provides the best reception. The laser diode which is paired with the identified phototransistor is selected and thereafter used to communicate with the backbone network. In this case, a laser diode number 5 would most likely be selected. Similarly, the hub access point 701 selects laser diodes based on received infrared transmissions for each of the tap access points 703, 705, 707 and 709. The tap access points 703 and 707 would most likely be assigned laser diode number 2 and number 8, respectively. The tap access points 705 and 709 would likely be assigned the same laser diode, laser diode number 1.

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The hub access point 701 controls communication by independently polling each of the tap access points 703, 705, 707 and 709 in succession. Such polling is conducted using the laser diodes selected for each tap access point. For example, the hub access point 701 first polls the tap access point 703 using the laser diode number 2. If no response is received, indicating that no communication is needed, or after a communication exchange has terminated, the hub access point 701 polls the tap access point 705 via the laser diode number 1. Afterwards, using the same laser diode number 1, the hub access point 701 polls the tap access point 709. Thereafter, the tap access point 707 is polled. To communicate with the backbone network, the hub access point 701 begins to listen for a polling message from other hub access points located down the hallway, the hub access point 715. When a polling message is detected, the hub access point 701 relays information to or from the backbone network as proves necessary. After such relaying has been completed (or after a predetermined time period), the hub access point 701 restarts the polling process by polling the tap access point 703. Further detail regarding this process is provided in reference to Fig. 8 below.

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Fig. 7d provides a cross sectional view illustrating the interaction of an infrared transmission of a laser diode 735 with one embodiment of a panel. The laser diode 735 is fitted with a horizontally shaped aperture, an aperture 737. With the aperture 737, the laser diode 735 produces infrared light in a very thin vertical beam, yet with a forty five (45) degree spread horizontally.

A panel 739 is installed for at least two reasons. First, the panel 739 contains infrared transmissions on either side of the panel, each panel helping to create two autonomous infrared communication cells. Such containment proves highly beneficial in establishing higher throughput communication protocols, such as the exemplary protocol detailed herein.

Second, the panel 739 minimizes reflection of a beam from the laser diode 735 toward any phototransistor that might happen to be located in the reflection pathway. To minimize such reflection, the surface of the panel 739 is designed to absorb or deflect infrared beams. Specifically, the surface is black with a rough texture to maximize absorption, and is angled so as to deflect incoming beams downward, away from the plane of phototransistors. Although not illustrated, such panels or surfaces might also be

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placed along any wall to further minimize reflection.

Moreover, the ceiling might also receive the black texture for similar reasons.

Fig. 8 is a timing diagram illustrating, in more
5 detail, the exemplary polling protocol used to
maintain communications through the communication
network set forth in Fig. 7b, and which is equally
applicable to Figs. 7a or 7b. Time lines (a)- (i) of
Fig. 8 represent communication transmissions and
10 receptions at a hub access point, such as the hub
access point 701 (Fig. 7c). In particular, referring
to Figs. 7c and 8, the time line (a) represents the
laser diode 2 engaging in polling transmissions from
the hub access. point 701 to the tap access point
15 703. The time line (b) represents transmissions
received by the hub access point 701 from the tap
access point 703 which are responsive to the polling
transmissions of the time line (a) similarly, the time
line (c) represents the laser diode 1 engaging in
20 polling transmissions to the tap access points 705 and
709, and their responses received by the hub access
point 701 are represented by the time line (d). The
time line (e) represents polling transmissions from
the laser diode number 8 of the hub access point 701
25 to the tap access point 707, and responses received by
the tap access point 707 is illustrated by the time

-33-

line (f). The time line (g) represents the lack of activity on all non-utilized infrared transceiver pairs and the non-utilized RF transceiver. In the time line (h), the hub access point 701 is shown in a listening state, awaiting polling from other hub access points in the backbone network. Finally, the time line (i) represents the polling messages received from another hub access point in the backbone network.

More specifically, at a time to as illustrated on the time line (a), the hub access point 701 begins the communication cycle by transmitting a polling message 801 to the tap access point 703. Thereafter, as illustrated in the time line (b), the hub access point 701 listens for a response. If a response is not detected within a timeout period, the period ending at a time t1, the hub access point 701 sends another polling message, a polling message 803, to the tap access point 705 as illustrated by the time line (c).

Again the hub access points awaits a response during a timeout period ending at a time t2. Since no response is received, as illustrated by the time line (d), the hub access point 701, transmits a polling message 805 to the tap access point 709. Again, no response is detected by the time out period ending at a time t3, as illustrated by the time line (e). Thereafter, the hub access point 701 transmits a

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polling message 807, and receives no response during the time out period as illustrated by the time lines (e) and (f). At this point, because there are no other tap access points to poll, the hub access point 5 701 enters a listening mode, awaiting polling messages from another hub access point located down the hallway, as illustrated by a time bracket 809 in the time line (h). Although the hub access point 701 has received no information to forward to the backbone 10 network, the listening period is required to determine whether information from the backbone network is awaiting delivery through the hub access point 701. Upon receiving a polling message 811 on the time line (i), the hub access point 701 determines that no 15 information from the backbone network is waiting. Thus, the entire cycle repeats itself.

Again, as illustrated in the time line (a), the hub access point 701 sends a polling message 815. However, before the time out period lapses, the tap 20 access point 703 responds with a data message 817, as illustrated by the time line (b). since the transmission was successfully received, the hub access point 701 transmits an acknowledge message 819, otherwise the data message would have to be resent. 25 Although the data message 817 received is directed through the backbone network, had it been destined to

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another of the tap access points which the hub access point services; the existence of the data message 817 would be indicated in the subsequent polling message to that destination tap access point. Upon receiving the subsequent polling message, the hub access point 701 would then route the message to the destination tap access point. However, in this situation, the data message 817 is stored for routing through the backbone network. Thereafter, the hub access point 701 continues the polling process by transmitting a polling message 821 to the tap access point 705. The tap access point responds, as illustrated in the time line (d), by transmitting a data message 823. The hub access point 701 receives the data message 823 and responds with an acknowledge message 825. Again, because the data message 823 is destined for the communication through the backbone network, the hub access point 701 stores the message for future transfer. Thereafter, polling messages 827 and 829 are sequentially transmitted to the tap access points 709 and 707, and no response to either is received before the time out periods, as illustrated by the time lines (C) through (f). The hub access point 701 enters a dormant listening mode during a time bracket 831, see the time line (h), and detects a polling message 833 from the hub access point in the backbone

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network, see the time line (i). In response, the hub
access point 701 forwards the stored messages 817 and
823 to the backbone network as data messages 835 and
837, respectively. The hub access point down the
5 hallway provides acknowledge messages 839 and 841 if
the data messages 835 and 837 are correctly received.

Failed transmissions will be retried. After
forwarding the data messages, the hub access point 701
then begins the polling process again, by transmitting
10 polling messages 843, 845, 847 and 849. Lastly, in
response to the polling message 849, a data message
851 is received by the hub access point 701 from the
tap access point 707, and the process continues.

Fig. 9 is a timing diagram illustrating the
15 adaptive nature of the polling protocol used in the
selection of infrared and RF links. Time lines (a)
through (d) represent a communication exchange wherein
infrared transmissions from the tap access point 709
are not successfully received by the hub access point
20 701, even though the tap access point 709 successfully
receives infrared polling messages. The time line (a)
illustrates transmissions by the hub access point
using an infrared source. The time line (b)
illustrates corresponding receipt of infrared
25 transmissions from the tap access point 709 by the hub
access point 701. The time line (a) represents RF

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transmissions from the hub access point 701, while the time line (d) represents RF transmissions received by the hub access point 701.

In particular, as illustrated in the time lines (a) and (b), the hub access point 701 transmits an infrared polling message 901. The tap access point 709 successfully receives the poll and transmits an infrared data message 903. However, the hub access point 701 does not receive the message 903 correctly. Therefore, instead of sending an acknowledge message, the hub access point 701 transmits an infrared resend message 905. Again, the tap access point 709 successfully receives the transmission and responds by resending the data as an infrared data message 907. Because the tap access point fails to properly receive the data a second time, an infrared resend message 909 is transmitted indicating that an RF transmission is justified. After a short delay, the hub access point 701 transmits an RF polling message 911. In response, the tap access point 709 resends the data as an RF data message 913. Finally, because the RF data message 913 is successfully received, the hub access point 701 sends an RF acknowledge message 915. Thereafter, both access points 701 and 709 return to the infrared communication link, and, as illustrated, resume normal polling and data message transfer. If

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the amount of interference causes the hub to utilize the RF link to often, the hub access point 701 signals for technical assistance through the backbone network.

Time lines (e) through (h) in Fig. 9 illustrate another RF backup scenario in which polling messages from the hub access point 701 are not received by the tap access point 709. The hub access point 701 continues along its polling cycle, assuming that the tap access point 709 is receiving its infrared polling messages. After missing a series of polling messages for a duration of time 951, the tap access point 709 decides that something is wrong. The tap access point 709 transmits a help message 953 and waits for the hub access point 701 to finish its current tasks and respond. As soon as the current task has been completed, the hub access point 701 sends an RF polling message 955. In response, the tap access point 709 sends an RF data message 957, which is acknowledged with an RF acknowledge message 959. Thereafter, the access points 701 and 709 resume the polling cycle on the infrared link. Again, after a duration of time 961, the tap access point 709 determines that it can sense any infrared transmissions, and again transmits an RF help message 963. After an RF data message 965 is acknowledged, the infrared link is again restored. If the RF backup


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is required too often, technical assistance is again sent for along the backbone network. If the RF link is required all of the time, the RF link will become the polling default until the infrared link problem is fixed.

Moreover, although the protocol described in reference to Fig. 9 refers to an embodiment wherein infrared communication is used as the default while RF communication constitutes a backup channel, the opposite configuration might be used. specifically, RF communication could be used as the default mode with infrared constituting a backup. In such an alternate embodiment, the description associated with Fig. 9 still applies so long as the infrared and RF roles are reversed. Therefore, a further description of this alternative need not be repeated. These protocols are carried out via software routines running within each of the access points in the network.

Fig. 10 is a block diagram representing the circuitry found in access points constructed in accordance with the present invention. As illustrated, a processing circuit 1001 is connected to memory 1003 in a conventional manner. The memory 1003 provides storage for (i) software programming that defines the operating procedures for the processing

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circuit 1001, (ii) data messages to be relayed, and
(iii) communication parameters and other variables.

Operating pursuant to the program stored in the memory
1003, the processing circuit 1001 controls an RF
5 transmitter circuit 1005, an RF receiver circuit 1007,
an infrared transmitter circuit 1009 and an infrared
receiver circuit 1011 pursuant to the communication
protocol described in relation to Figs. 8 and 9.

The coaxial connectors shown in Figs. 2c-e
10 constitute the attachment points for antennas on an
antenna bus 1113. The radio transmitter and receiver
circuits 1005 and 1007 selectively utilize any
antennas that may be attached to the antenna bus 1113.

Such utilization occurs per the protocol stored in
15 the memory 1003.

The laser diodes of the hub access point
illustrated in Fig. 2d are attached to a drive bus
1115. The infrared transmitter circuit 1009 transmits
by selectively applying digital data onto ones of the
20 plurality of drive lines in the drive bus 1115. The
applied digital data activates and deactivates
(modulates) the corresponding ones of the laser
diodes. In Fig. 2e, in the illustrated tap access
point, only a single drive line of the drive bus 1115
25 is needed to support the single laser diode.

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To receive infrared transmissions, the infrared receiver circuit 1011 provides a sensor bus 1117 which interconnects the circuit 1011 with the phototransistors shown in Fig. 2d. The infrared receiver circuit 1011 selects ones of the phototransistors via the sensor bus 1117 for monitoring after polling messages are transmitted (see the discussion relating to Fig. 8 above). For the tap access point of Fig. 2e, only a single sensor interconnect of the sensor bus 1117 is used.

Fig. 11 is a top cross-sectional view of an airplane configured with the access points of the present invention installed in a communication network having a server which interfaces with cockpit equipment. Specifically, an airplane 1151 is configured with a communication network comprising a server 1153, cockpit equipment 1155 and a backbone network involving a plurality of access points. Each access point services a plurality of infrared transceiver pairs to provide passengers with an interface to the communication network. Using their own equipment (such as a lap-top computer), passengers communicate with each other, the server and ground based resources while minimizing unacceptable interference with the cockpit equipment 1155.

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The server 1153 is located within a shielded enclosure 1181 to minimize RF noise emissions. Although located at the front of the airplane 1151, the server 1153 and enclosure 1181 might be located
5 anywhere within the plane. For example, if located at a position 1177, the cockpit equipment 1155 would benefit from being located further away from the server 1153 -- a source of RF noise.

The server 1153 contains local database
10 information (textual, graphic, etc.) regarding duty free goods, flight schedules, terminal information, promotional offerings and other flight information. The server 1153 also collects and stores flight information, such as air speed, direction, global
15 position, etc., from the cockpit equipment 1155 via a wired link 1183 for passenger perusal.

Additionally, the server 1153 provides access to wireless transceiving means, enabling passengers to access and retrieve data, information or messages from
20 ground based sources. Peripherals such as a printers and a fax machine (although not shown) are also connected to the server 1153 to provide the passengers typical small office support.

Forming the backbone of the network, the
25 plurality of access points are each represented by a small square, e.g., access points 1161, 1163, 1165 and

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1173. These access points are identical to those described above and, in addition, supports remotely located infrared transceiver pairs.

Each of the plurality of infrared transceiver pairs are represented by small circles, e.g., infrared transceiver pairs 1159, 1167, 1169 and 1171. Infrared transceiver pairs are disposed at locations above each passenger's tray-table for communicating with a passenger's electronic equipment located thereabout.

In each row, six seats (not shown), e.g., 11A, 11B, 11C, 11D, 11E and 11F for the eleventh row, correspondingly have six infrared transceiver pairs located thereabove.

Also in each row, the three left-most infrared transceiver pairs are communicatively coupled via wired links to the corresponding left-most access point. Likewise, the right-most access point is attached via wired links to the three right-most infrared transceiver pairs. In this configuration, two access points service all of the infrared transceiver pairs found in a single row. In other installations, a single access point might be configured and located to service several rows or to service only one infrared transceiver pair.

The access points located on the left side of the airplane, such as the access points 1165 and 1173, are

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also communicatively coupled to each other and to the server 1153 via a communication pathway 1175. Similarly, the access points on the right side of the airplane (such as the access points 1161 and 1162, are coupled with each other and the server 1153 via a communication pathway 1176.

As illustrated, the server 1153 provides routing / intelligent bridging between the pathways 1175 and 1176. Alternately, the communication pathways 1175 and 1176 can be combined into a single pathway should such a configuration prove desirable.

The communication pathways 1175 and 1176 can be constructed in several different ways. In one embodiment, the communication pathways 1175 and 1176 constitute coaxial Ethernet links, although alternate types wired links might be employed. Coaxial links offers high bandwidth at a relatively low cost, yet may prove unacceptable in some installations because of the inherent RF noise associated therewith. To minimize such noise, the coaxial cable can be housed in a shielded passageway behind the overhead luggage bins.

In another embodiment, to overcome the RF noise associated with wired links, fiber may be employed for the communication pathways 1175 and 1176. However, fiber links are substantially more expensive than

wired links.

Infrared (wireless) transmissions are used in another embodiment to establish the communication pathways 1175 and 1176. This embodiment offers a lower-cost alternative to fiber with no RF noise problems. With this embodiment, however, overall bandwidth is typically reduced.

In each of the aforementioned communication pathway embodiments, if the link breaks down, communication will be interrupted. To overcome this and other problems, another and preferred embodiment comprises two types of links for each of the communication pathways 1175 and 1176. For example, fiber and infrared links or fiber and coaxial links might be employed. Preferably, however, the communication pathways 1175 and 1176 each comprise both a wired and an infrared link.

Whenever the cockpit equipment 1155 experiences unacceptable levels of RF interference and during the critical periods of take off and landing, the cockpit equipment 1155 delivers an "idle command" along the low-bandwidth (low noise) wired link 1183 to the server 1153. The server 1153 responds by suspending all communication on the communication network, i.e., commands the plurality of access points to enter a wait state and not to utilize the communication

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pathways 1175 or 1176.

After critical periods or periods in which unacceptable RF interference has ended, the cockpit equipment 1155 sends a "resume command" to the server 1153 via the link 1183. In response, the server 1153 forwards the command to each of the plurality of access points and communication resumes.

As mentioned previously, in the illustrated embodiment, the communication pathways 1175 and 1176 comprise both a coaxial and a infrared link. In such a configuration, resumed communication involves nearly all information flowing through the coaxial link pursuant to an ethernet protocol.

During periods in which RF noise is not entirely unacceptable but proves annoying to the cockpit equipment 1155, the cockpit equipment sends the server 1153 a "reduce noise command." In response, the server 1153 temporarily redirects communication flow from the coaxial to the infrared links. Upon receiving a resume command, the server 1153 redirects communication flow back to the coaxial link.

Much of the subcomponent parts of the cockpit equipment 1155 can be configured to automatically provide the idle, reduce noise and resume commands based on detected noise or events (such as take off) or upon actual use. For example, a cockpit radio

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SUBSTITUTE SHEET (RULE 26)

-47-

might detect noise and send a reduce noise command to the server 1153. The radio might also send an idle command to eliminate detected noise while a crew member utilizes the radio in a communication exchange.

5 In addition, the cockpit crew can manually interact to deliver such control messages to the server 1153 as they see fit.

With the network in a resume or reduced noise mode, a passenger with a computer terminal coupled
10 through the infrared transceiver pair 1167, for example, could communicate with another such passenger coupled through the infrared transceiver pair 1171. Communications between the two would flow through the access point 1165, along the communication pathway
15 1175 to the server 1153, through the server 1153, along the communication pathway 1176 and, finally, through the access point 1163.

The passenger coupled through the infrared transceiver pair 1167 could also communicate with a
20 passenger coupled to the infrared transceiver pair 1187. However, in this case, communication flow would only involve the access device 1165. Thus, even if the communication link 1175 broke down or was otherwise restricted, communication between the
25 collocated passengers could be maintained.

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Also, the passenger coupled to the infrared transceiver pair 1167 can access the server via the access point 1165 and the communication link 1175. Such access may be for sending or receiving remote or local information, performing remote or local processing or utilizing server peripherals.

The communication pathways 1175 and 1176 also implement the backup procedures discussed above in reference to previous figures. For example, if ongoing communication using a wired link between two access points breaks down, the access points will reroute the communication through the infrared channel, and vice versa. Further, the general functionality and operation of the access points described above (in reference to previous Figs.) applies to the present airplane embodiment as well.

Fig. 12 is a front cross-sectional view of the airplane of Fig. 11 illustrating access point and infrared transceiver pair positioning. In the airplane 1151, infrared transceiving pairs 1201, 1203 and 1205 are directly wired to an access point 1223 located behind a luggage bin 1227. Similarly, infrared transceiving pairs 1207, 1209 and 1211 are wired to an access point 1221 located behind an overhead luggage bin 1225. The infrared transceiving pairs 1201, 1203, 1205, 1207, 1209 and 1211 are

located underneath the overhead bins 1225 and 1223 along with other passenger controls.

Through the infrared transceiving pairs, a passenger's equipment that uses its own infrared transceiver pair may coupled to the network. For example, a passenger located in a seat 1231 may couple a portable computer 1233 sitting on a tray-table 1235 to the network via its own transceiver pair (not shown) and the infrared transceiver pair 1207. The transceiver pair 1207 is directed so as to create a small cone-shaped infrared cell 1237 encompassing the tray-table 1235. With the small cell, interference from neighboring infrared transmissions are minimized.

Thus, the passenger in the seat 1231 can communicate with the server 1153 (Fig. 11) or any other passenger, such as a passenger in a seat 1241, through the communication network.

Additionally, if infrared transmissions are employed in the communication pathways 1175 and 1176 as installed, blocking panels are installed at each access point to create cells between each pair of access points. For example, a blocking panel 1251 prevents infrared transmissions originating at an access point one hop closer to the server 1153 than the access point 1221 from reaching an access point one hop further away from the server 1153 than the

access point 1221. Likewise, the blocking panel 1251 prevents infrared transmissions originating at the access point one hop further away from reaching the access point one hop closer. All of the plurality of
5 access points utilize such blocking panels.

In other words, the access point 1221 participates in a first cell with the access point one hop closer to the server, and in a second cell with the access point one hop further away. Each of the
10 plurality of access points similarly participate in two cells created by blocking panels.

Fig. 13 is a perspective view of an overhead control panel 1301 modified in accordance with the present invention to accommodate a infrared
15 transceiver pair. In particular, a typical overhead control panel comprises an air conditioning valve 1303, a paging button 1305 and a light 1307 with an associated on/off switch 1309. The control panel 1301 further includes an infrared transceiver pair 1311 and
20 an associated enable switch 1313. By pressing the switch 1313, an access point that is coupled thereto and to the infrared transceiver pair 1311 responds by enabling infrared communication to the passenger's equipment.

25 Although not required, the switch 1313 further assists in isolating infrared communication from

-51-

neighboring passenger's non-utilized cells. The access point utilizes a polling protocol (although other protocols might be used) to communicate with the passenger's equipment. Thus, by toggling the switch
5 1313 off, the access point will ignore the infrared transceiving pair 1311 in carrying out its polling protocol.

Although the infrared transceiving pair 1311 is aimed at fixed location in the center of a tray-table,
10 the pair 1311 might alternately be mounted with a ball in socket joint, for example, to provide for adjustable aiming. Moreover, although not preferred, the transceiver pair 1311 might alternately be mounted within the tray-tables or armrests, for example, or on
15 the back of the airplane seats. Similarly, although not preferred, the armrest, for example, may contain a direct wired connection to the access points, eliminating the infrared transceiver pairs yet creating more RF noise due to the increased number and
20 length of wired links.

Fig. 14 is a block diagram of the communication network in the airplane of Fig. 11 detailing the functionality and interaction of the server. The server 1153 comprises processing circuitry 1401, local
25 storage 1403 and interface circuitry 1405. The server 1153 is communicatively coupled with: 1) cockpit

SUBSTITUTE SHEET (RULE 26)

-52-

equipment via the wired link 1183; 2) passengers via the communication pathways 1175 and 1176; 3) peripherals such as a printer 1415 and a fax machine 1417; and 4) remote resources via transceivers 1411 and 1413.

Communication outside of the airplane to remote ground-based resources may take one of many paths. For example, the transceiver 1411 operates with an antenna 1421 to communicate with satellite transceivers (not shown). In turn, the satellite transceivers relay the information to a ground based stations then routed to the remote resource, and vice versa. Alternately, direct communication from the airplane to a ground based transceiving station can take place via the transceiver 1413 and associated antenna 1423. Packetized voice data, information, messages, requests, etc., can be sent through either path.

More particularly, for example, either transceiver 1413 or 1421 may be used to communicate with an Internet point of presence or service provider via a ground-based access transceiver 1431 via an antenna 1433. Communications received are then forwarded through a link 1435 to the Internet network.

With such connectivity, a passenger could browse the Internet, send or receive Email, etc., while in

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flight. Similarly, telephone links could be set up with corresponding wireless access transceivers into the telephone network.

It is obvious that the embodiments of the present invention described hereinabove are merely illustrative and that other modifications and adaptations may be made without departing from the scope of the appended claims. For example, it should be evident that the configuration of the present invention within the airplane would apply equally well in any other environment in which RF noise or transmissions occasionally cause unacceptable interference with sensitive equipment. For example, such equipment need only provide a server of the present invention control signals relating to such detected noise or prohibited time periods, and the network will adapt itself to minimize interference. Many other such modifications and implementations are clearly possible without departing from the scope of the claims.

WE CLAIM:

1. A communication network for maintaining communication among a plurality of end-point devices, said network comprising:

5 a plurality of end-point devices each having an infrared transceiver or a radio frequency transceiver or both;

a plurality of access point devices each having an infrared transceiver and a radio frequency transceiver;

10 said plurality of access point devices arranged to provide a communication pathway between the first and second end-point devices through each of the plurality of access point devices; and

15 to maintain the communication pathway between the first and second end-point devices, each of said plurality of access point devices utilize a preferred one of either the infrared transceiver or the radio frequency transceiver whenever possible, else utilize the other of the infrared transceiver and
20 radio frequency transceivers.

2. The communication network of claim 1 wherein at least one of said plurality of access point devices is located within an area physically separate from the plurality of end-point devices.

3. The communication network of claim 1 further comprising a panel for minimizing unwanted infrared transmissions.

4. The communication network of claim 3 wherein said panel minimizes unwanted infrared transmissions by absorption and angular deflection.

5. The communication network of claim 1 wherein the infrared transceiver constitutes the preferred one of either the infrared transceiver or the radio frequency transceiver.

6. The communication network of claim 1 wherein it is not possible to use the preferred one of either the infrared transceiver or the radio frequency transceiver if attempts to use the preferred one fail.

7. A communication network for maintaining communication among a plurality of end-point devices in an environment sensitive to RF interference, said network comprising:

5 a plurality of end-point devices;
 a plurality of access point devices;
 a communication pathway, comprising said plurality of access point devices, that supports communication among said plurality of end-point
10 devices;

 a device sensitive to RF interference;

 a control link coupled to said device through which signals indicative of acceptable levels of RF interference are communicated;

15 said communication pathway being capable of generating different levels of RF interference; and

 said communication pathway adjusting the level of RF interference generated based on the signals communicated via said control link.

8. The communication network of claim 7 further comprising a server responsive to said control link for relaying the signals indicative of acceptable levels of RF interference along said communication
5 pathway.


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9. The communication network of claim 8 wherein the server provides said plurality of end-point devices access to local and remote resources.

10. The communication network of claim 9 wherein the environment sensitive to RF interference constitutes an airplane, each of said plurality end-point devices constitutes a portable computer having
5 an infrared transceiving pair, and said plurality of access points each have a plurality of infrared transceiver pairs disposed within the airplane to support communication with ones of the plurality of end-point devices.

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SUBSTITUTE SHEET (RULE 26)

1/15

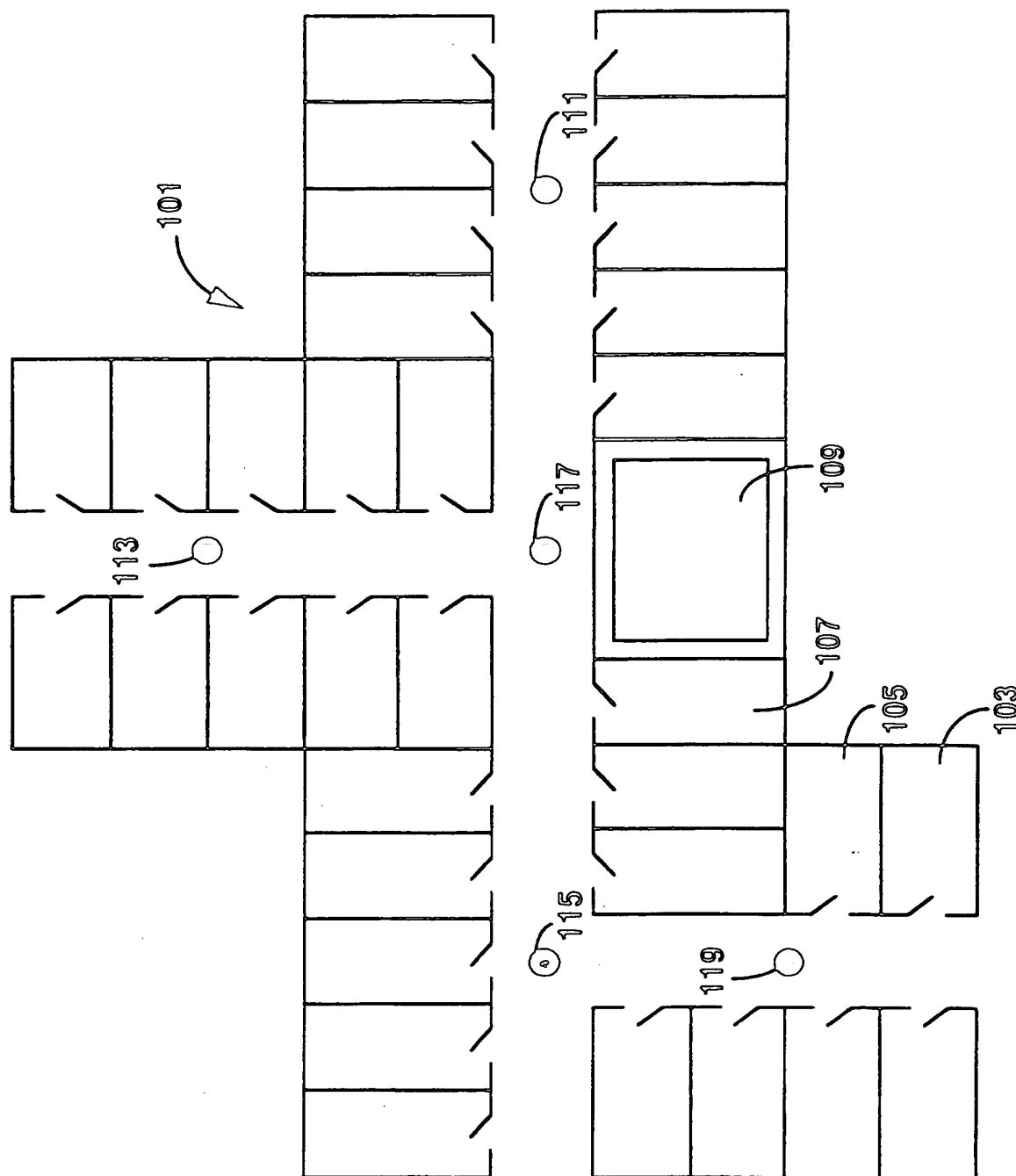


Fig. 1

2/15

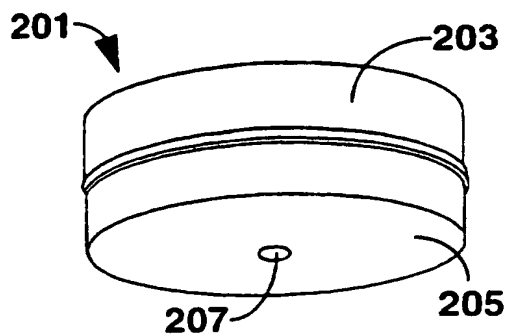


Fig. 2a

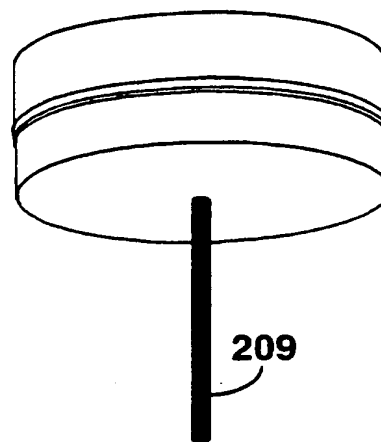


Fig. 2b

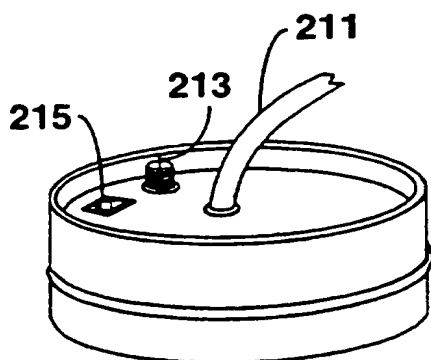


Fig. 2c

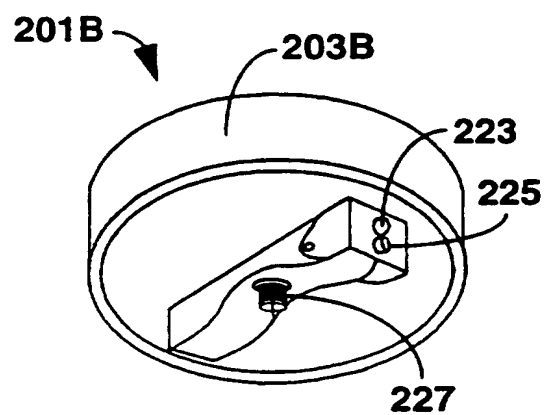


Fig. 2e

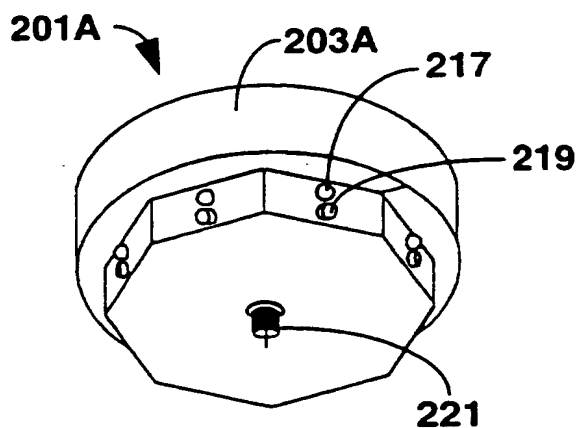


Fig. 2d

SUBSTITUTE SHEET (RULE 26)

3/15

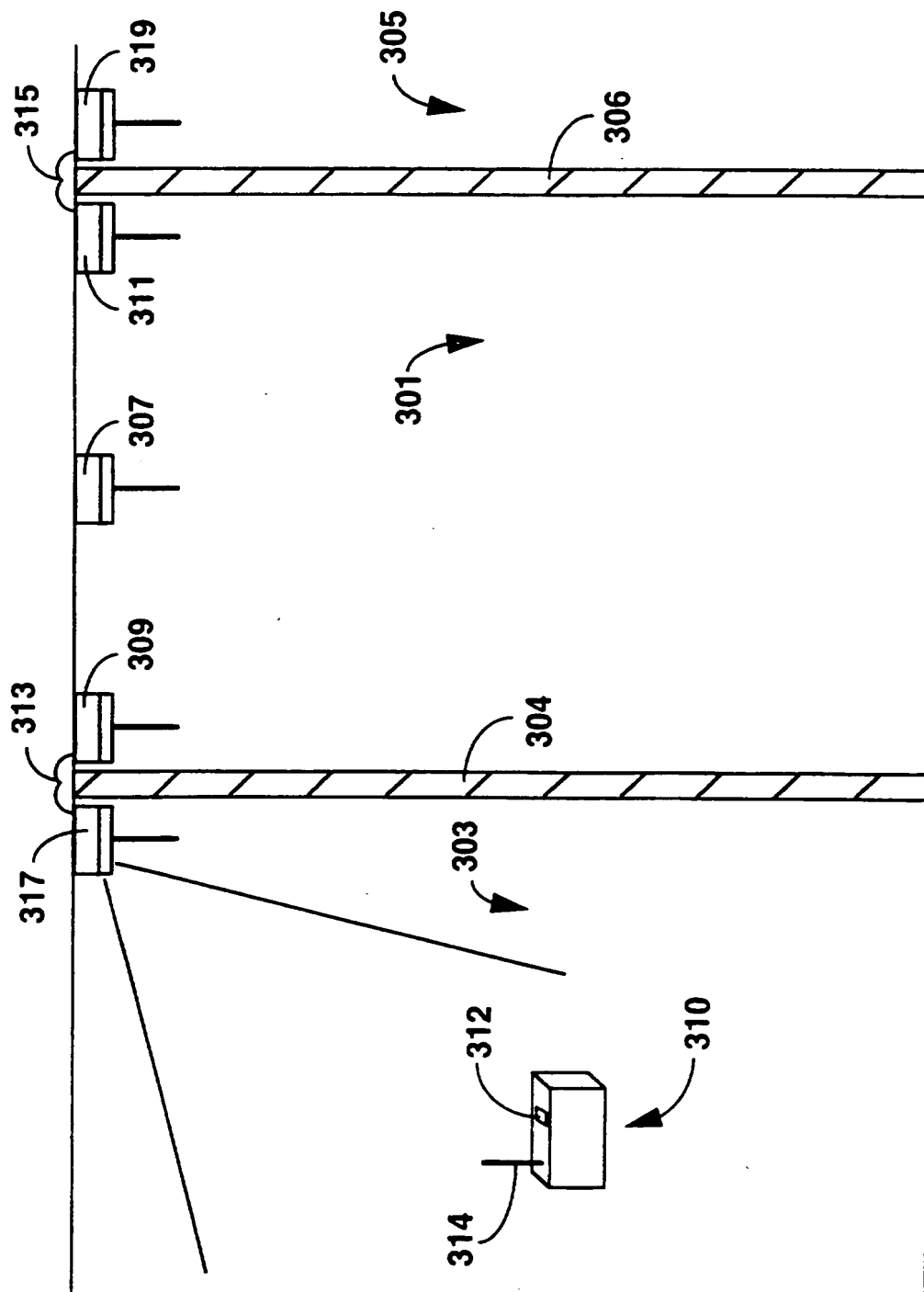


Fig. 3

4/15

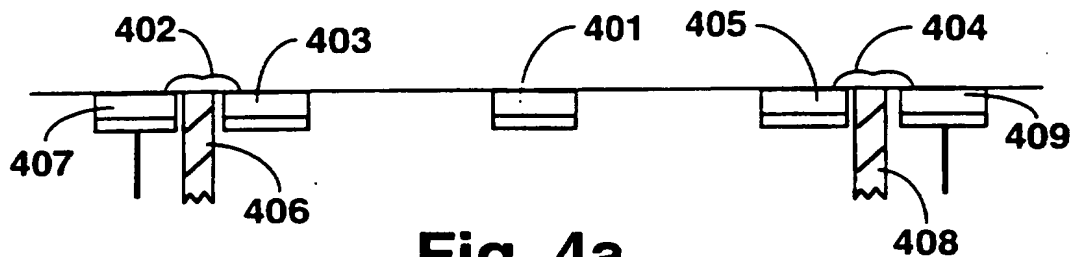


Fig. 4a

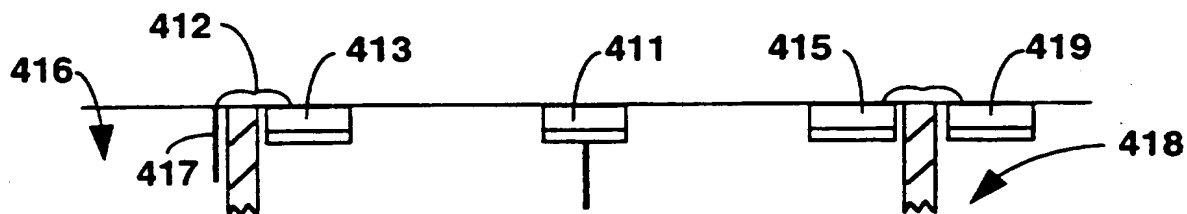


Fig. 4b

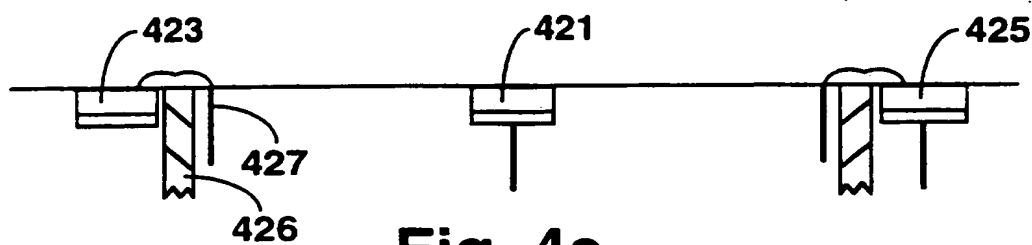


Fig. 4c

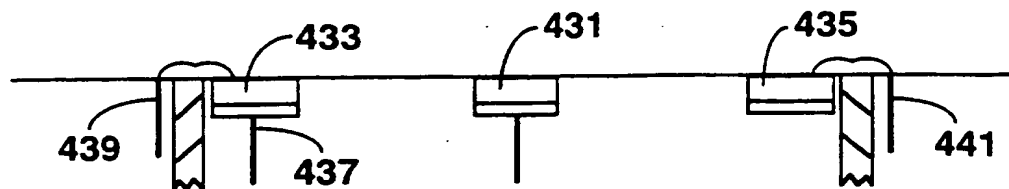


Fig. 4d

SUBSTITUTE SHEET (RULE 26)

5/15

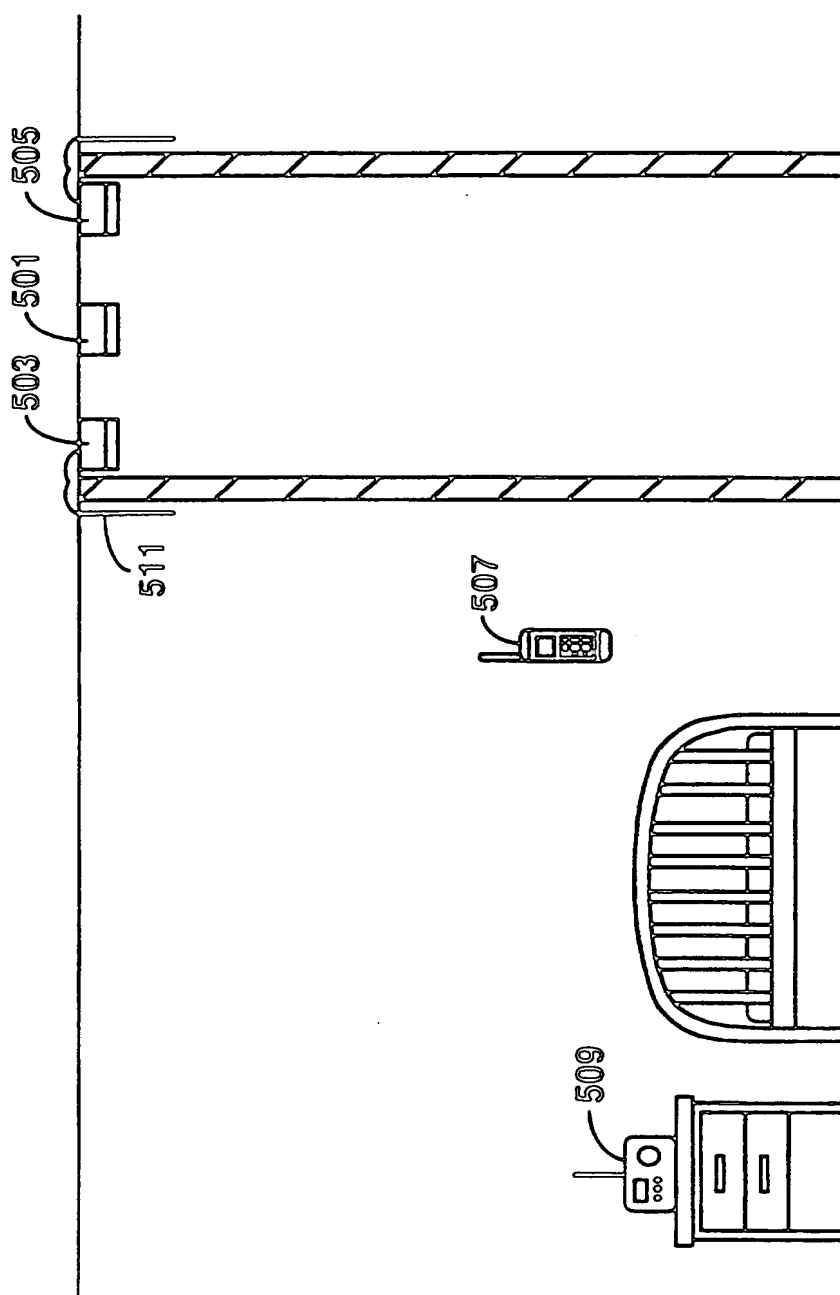


Fig. 5

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6/15

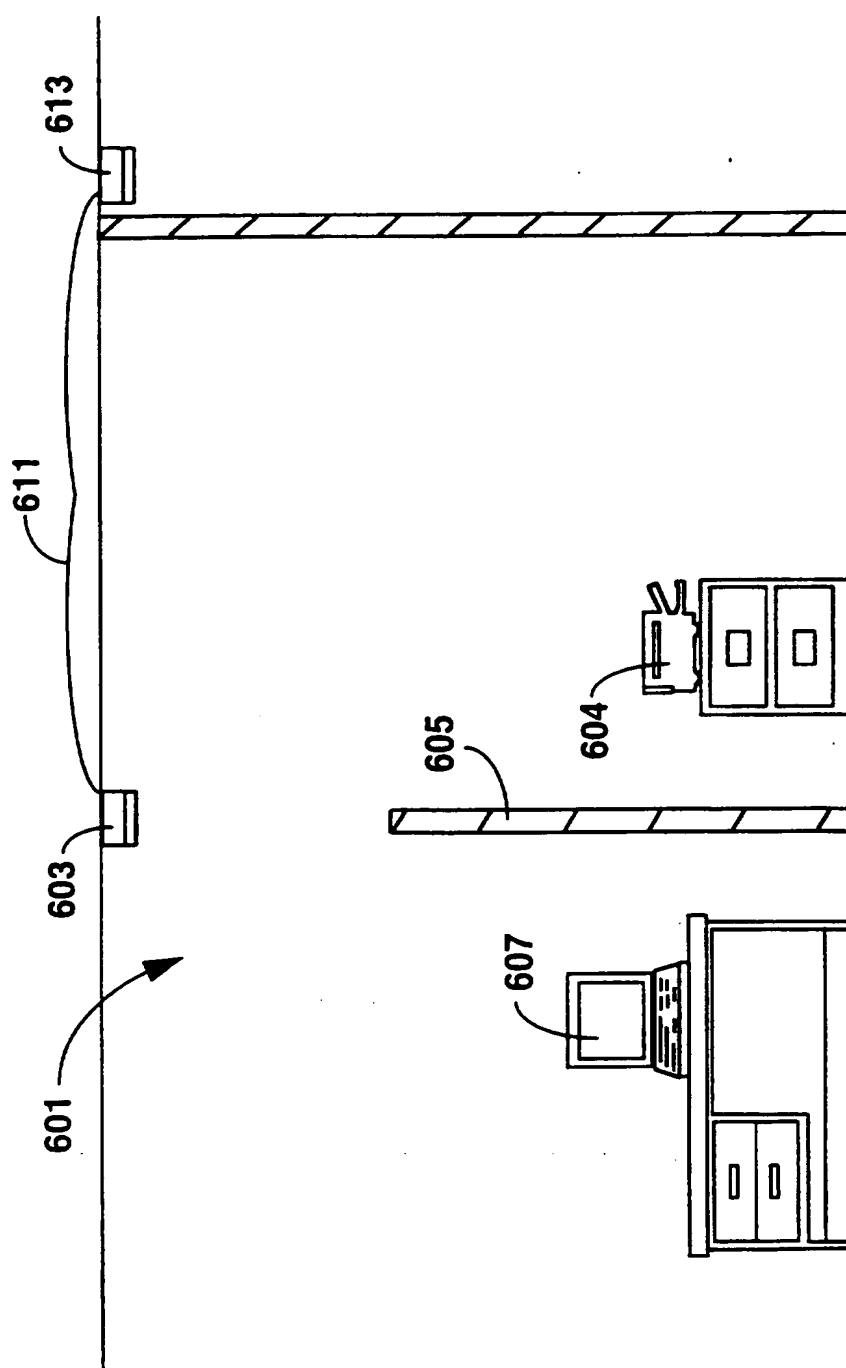


Fig. 6

7/15

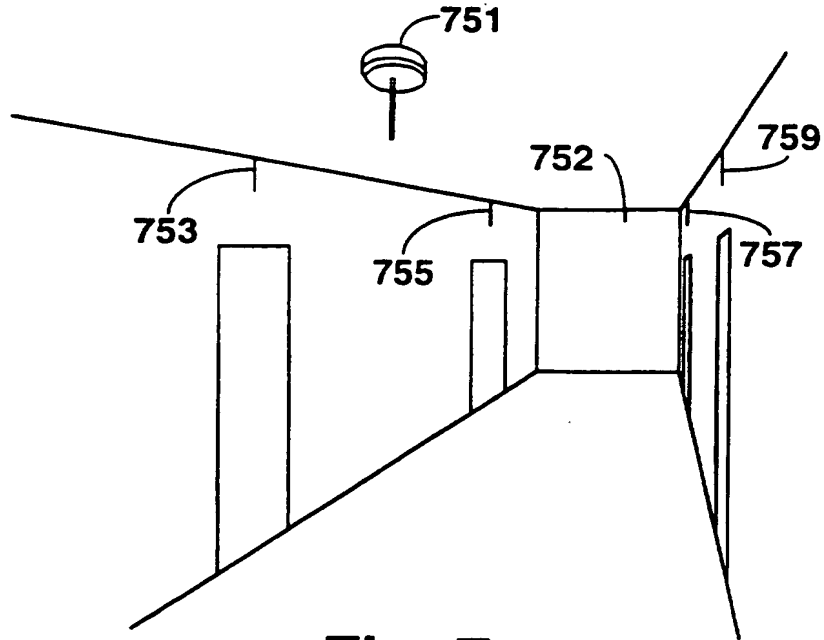


Fig. 7a

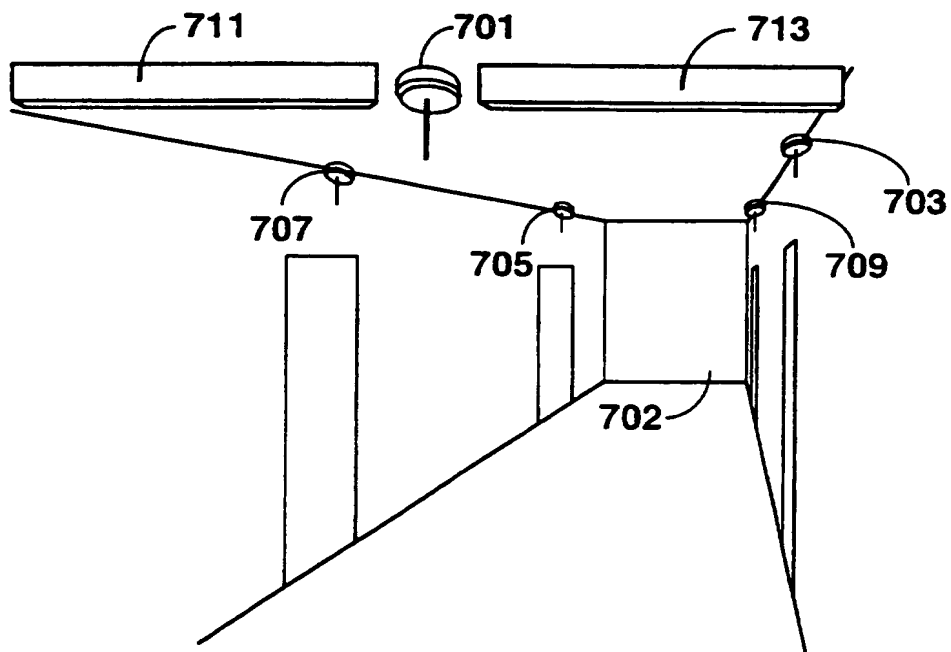


Fig. 7b

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8/15

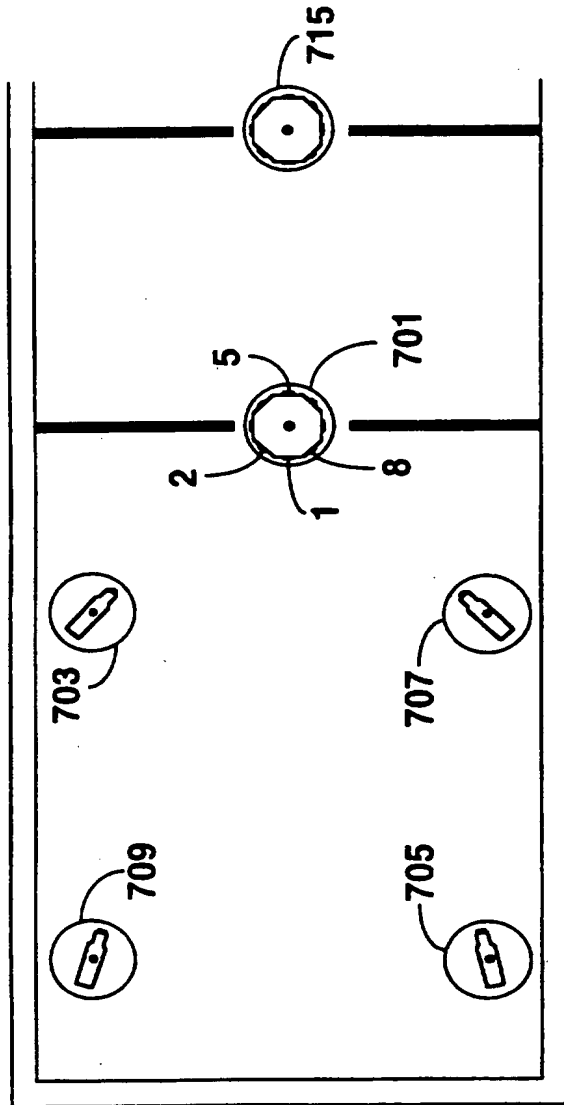


Fig. 7c

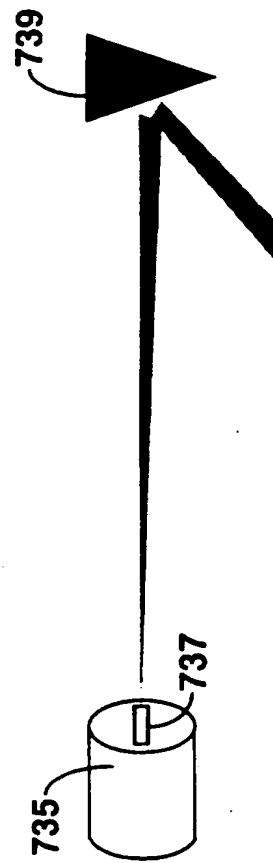


Fig. 7d

9/15

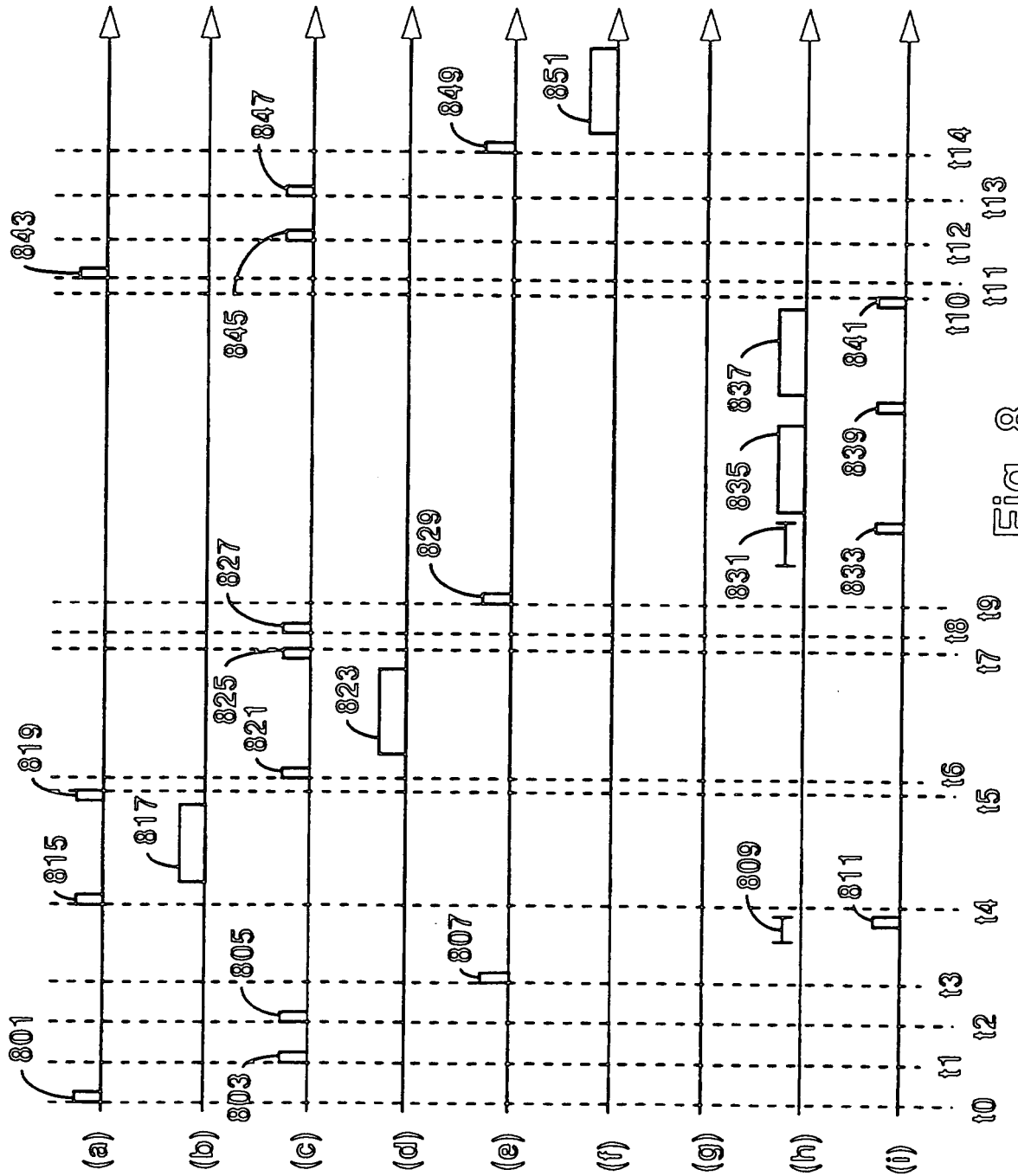


Fig. 8

10/15

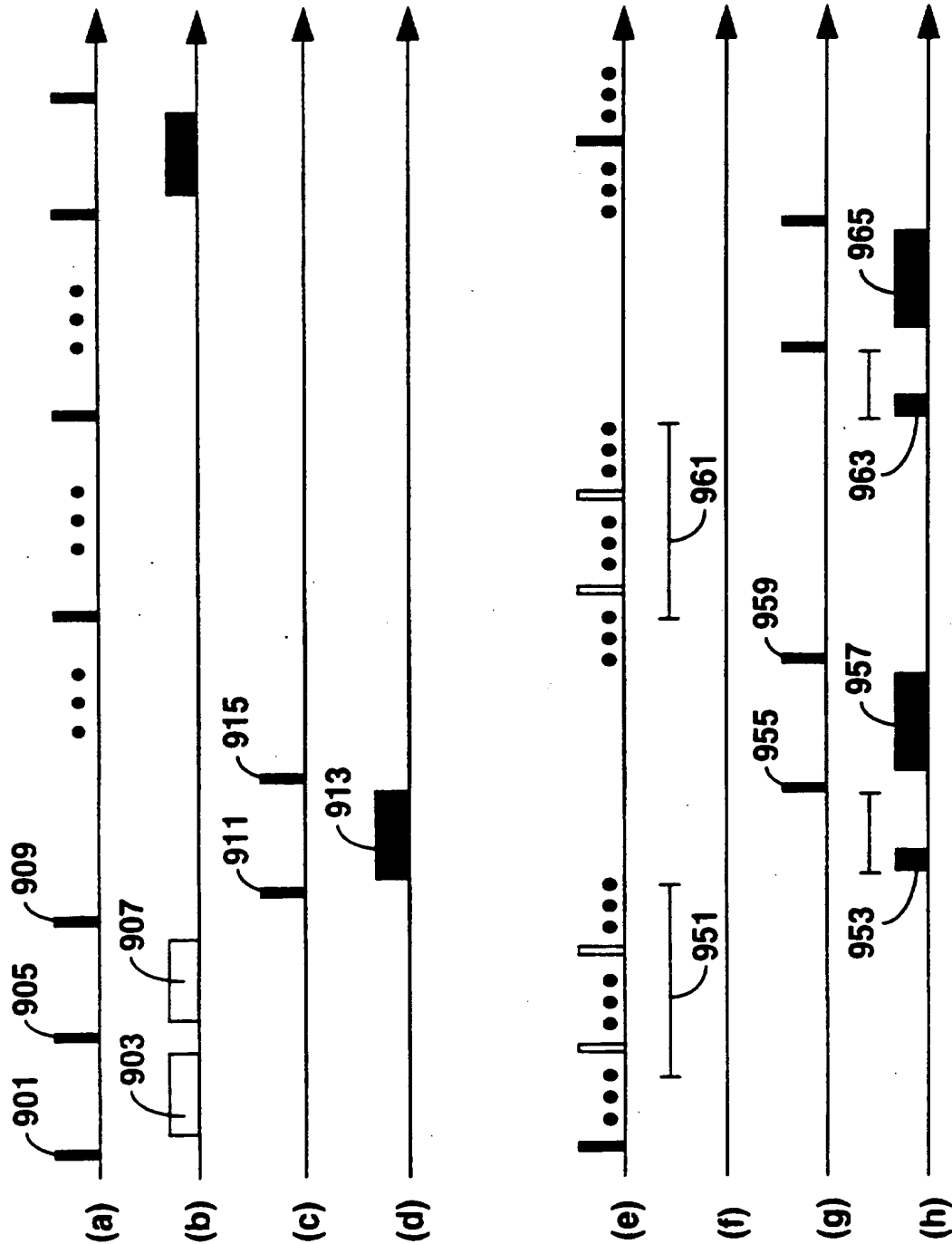


Fig. 9

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11/15

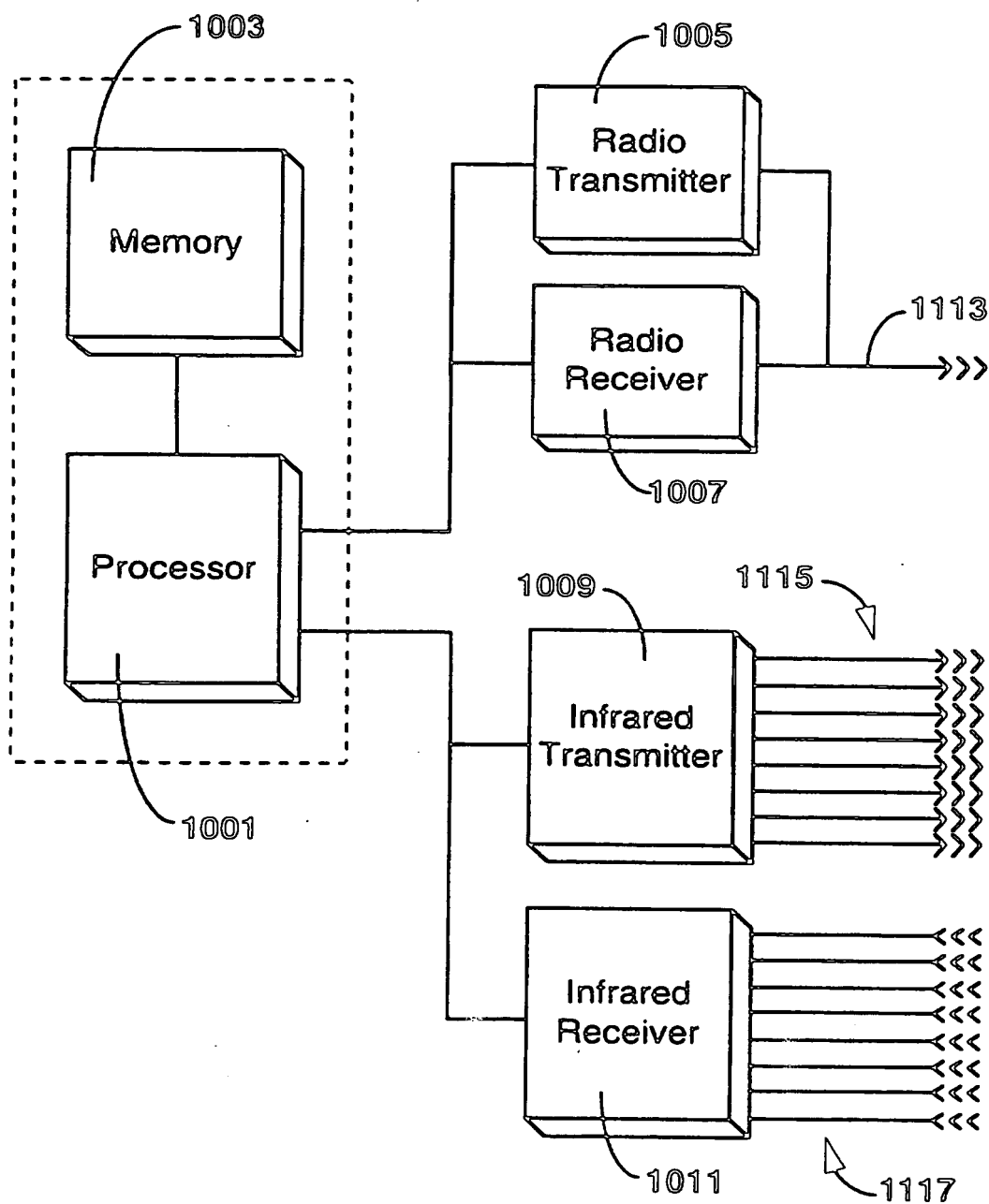


Fig. 10

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12/15

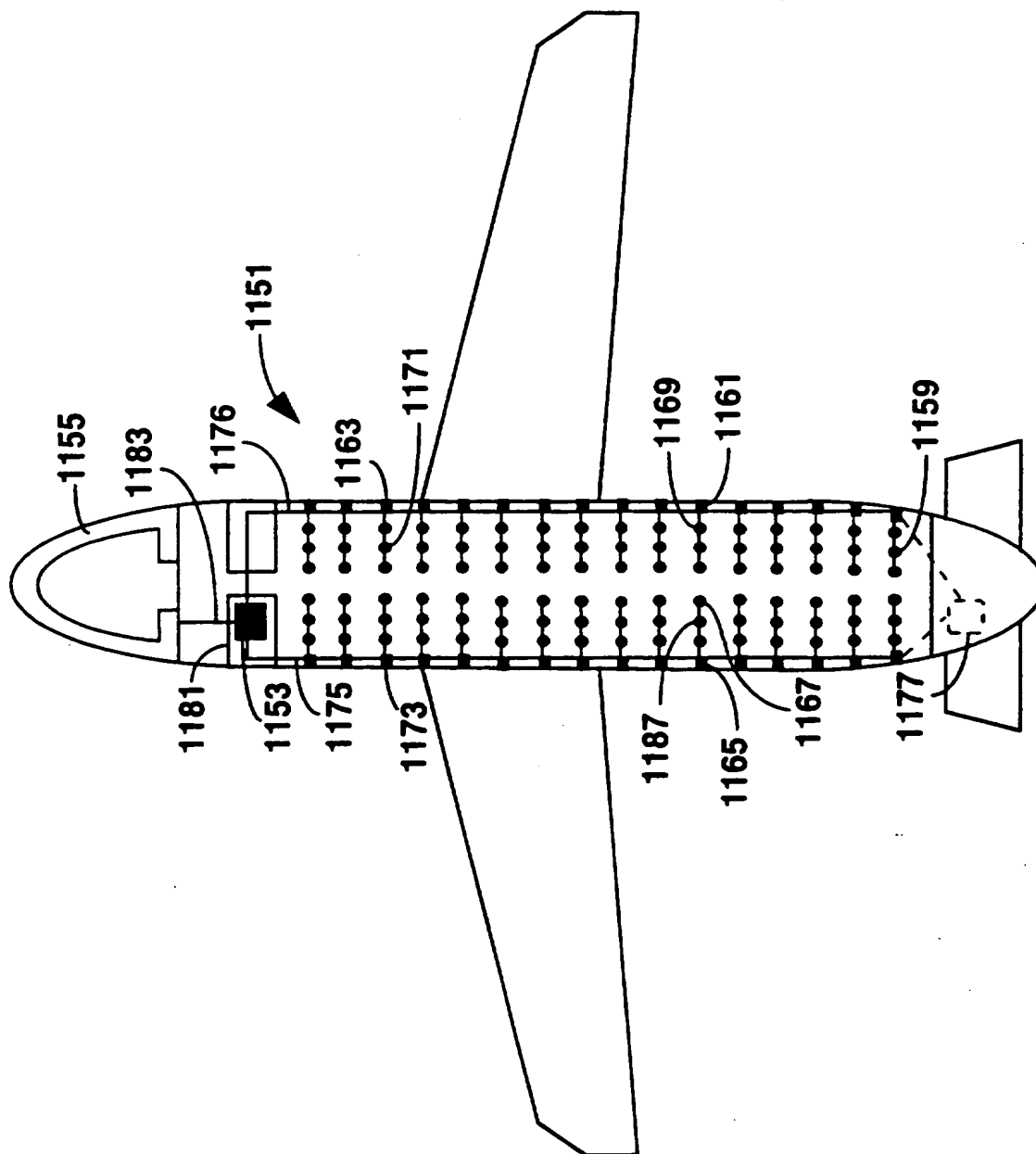


Fig. 11

13/15

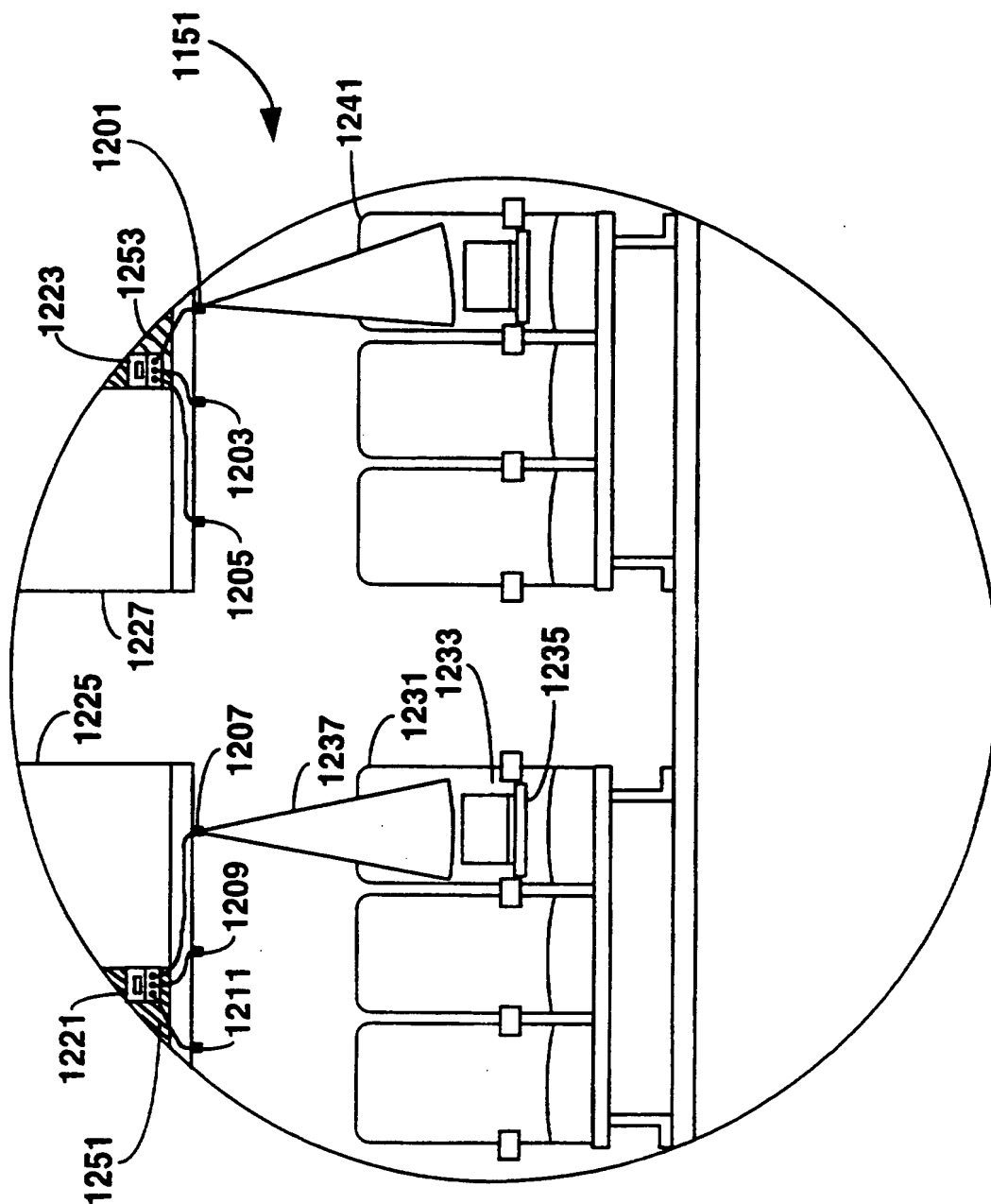


Fig. 12

14/15

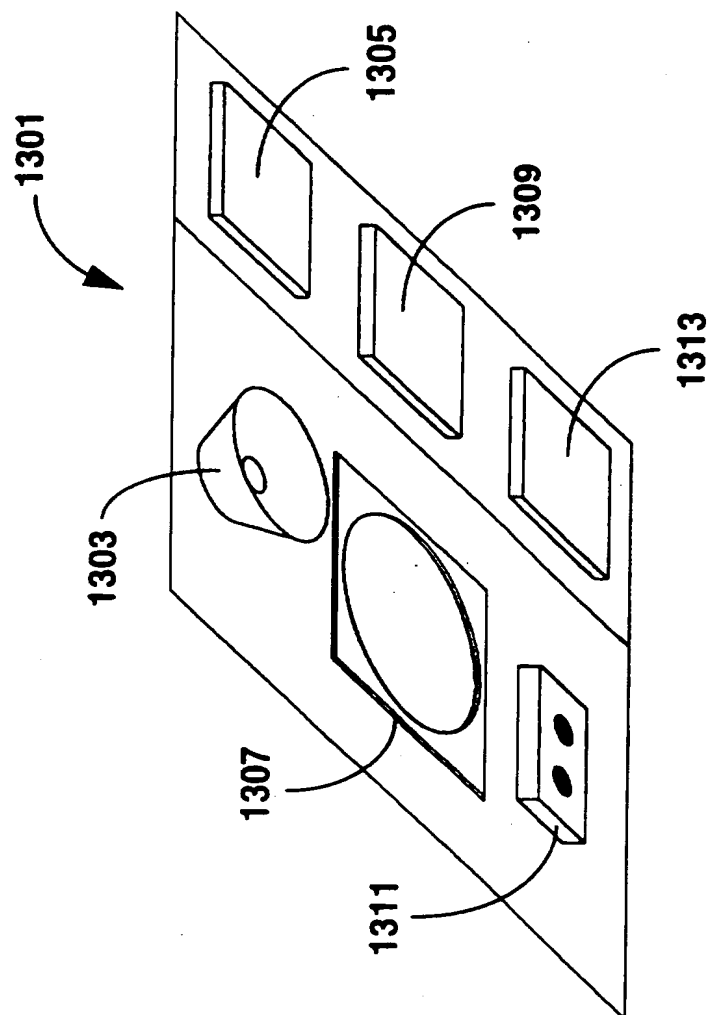


Fig. 13

15/15

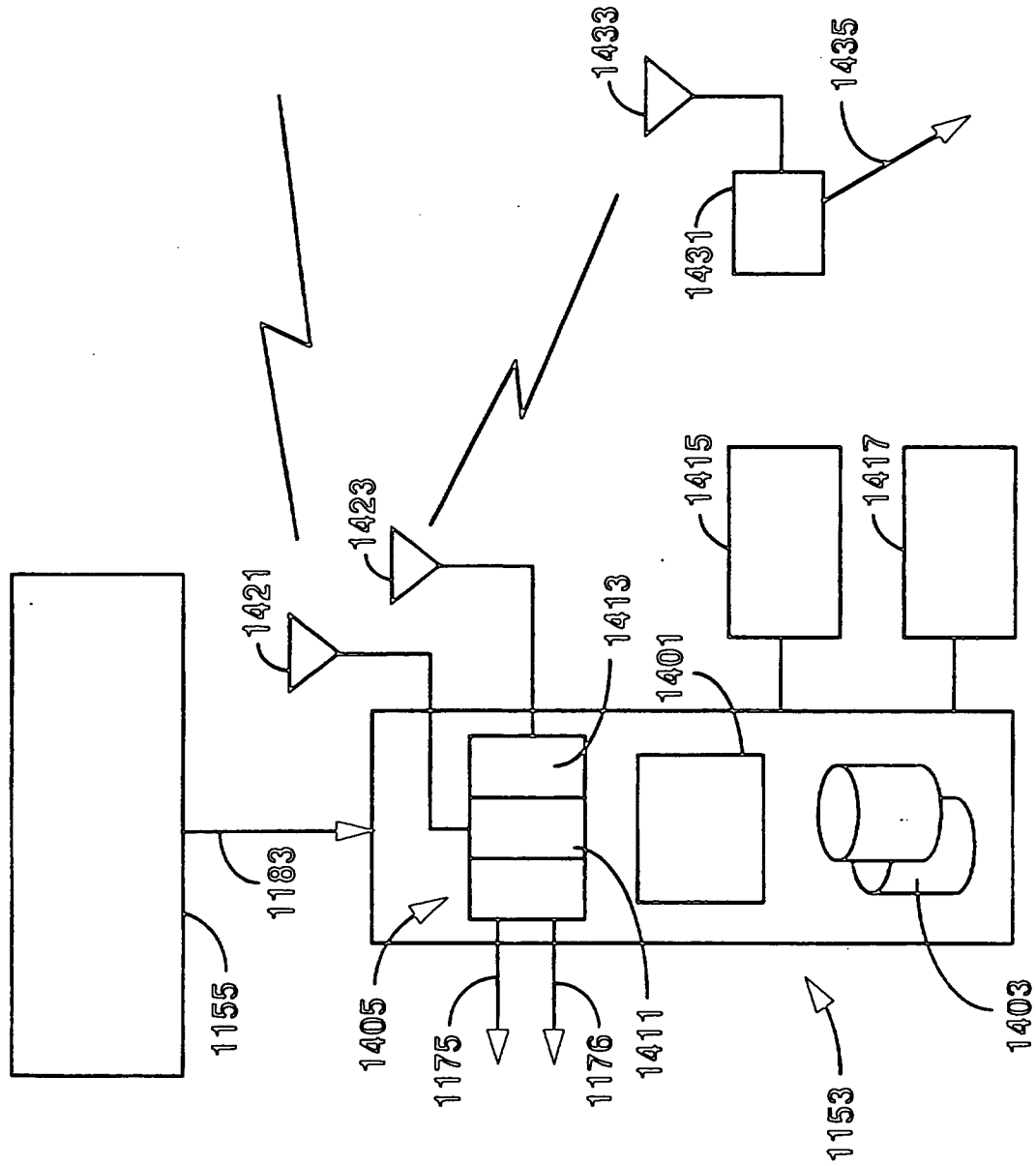


Fig. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/04396

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H04B 10/00 , 1/38, 1/40

US CL : 359/143,145,146,152,167,172; 455/73-74,90

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 359/143,145,146,152,167,172; 455/73-74,90

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US, A, 5,301,353 (BORRAS et al.) 05 April 1994. See all document.	1-9 ----- 10
X,P	US, A, 5,424,859 (UEHARA et al.) 13 June 1995. See all document.	1-9
A	US, A, 4,959,874 (SARUTA et al.) 25 September 1990. See all document.	1-9

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be part of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"A" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

19 JUNE 1996

Date of mailing of the international search report

15 JUL 1996

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